Materials and Fabrication of 2¼Cr-1Mo, 2¼Cr-1Mo-¼V, 3Cr-1Mo, and 3Cr-1Mo-¼V Steel Heavy-wall Pressure Vessels for High-temperature, High-pressure Hydrogen Service

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Introduction

This recommended practice (RP) applies to new heavy-wall pressure vessels in petroleum refining, petrochemical, and chemical facilities in which hydrogen or hydrogen-containing fluids are processed at elevated temperature and pressure. It is based on decades of industry operating experience and the results of experimentation and testing conducted by independent manufacturers and purchasers of heavy-wall pressure vessels for this service.

Licensors and owners of process units in which these heavy-wall pressure vessels are to be used may modify or supplement this RP with additional proprietary requirements.

Materials and Fabrication of 2¼Cr-1Mo, 2¼Cr-1Mo-¼V, 3Cr-1Mo, and 3Cr-1Mo-¼V Steel Heavy-wall Pressure Vessels for High-temperature, High-pressure Hydrogen Service

1 Scope

This RP covers materials and fabrication requirements for new 2¼Cr and 3Cr steel heavy-wall pressure vessels for high-temperature, high-pressure hydrogen service. For this RP, "heavy-wall" is defined as a shell thickness of 4 in. (100 mm) or greater, and "high-temperature" is considered to be operating temperatures of 650 °F (345 °C) and up to a maximum design temperature where ASME Section II-D:2023 Table 5A defines the threshold time-dependent properties for the given material classification and in compliance with API 941. This RP applies to pressure vessels that are designed, fabricated, certified, and documented in accordance with ASME Section VIII, Division 2, Class 2, including Paragraph 3.4, Supplemental Requirements for Cr-Mo Steels, and ASME Code Case 2151, as applicable.

Although outside of its scope, this RP can be used as a resource for pressure vessels with wall thicknesses below 4 in. (100 mm) or operating at temperatures of less than 650 °F (345 °C), or with maximum design temperature limits above the thresholds given in the paragraph above with changes defined by the purchaser. This document may also be used as a resource when planning to modify an existing heavy-wall pressure vessel.

ASME Section VIII, Division 3 is typically used for much higher-pressure applications (beyond the hydroprocessing range), and a specific ASME Code Case developed for these alloys is also available under Division 3. Division 3 has much stricter design rules (e.g., fatigue and fracture mechanics analyses are required) and material testing requirements, and application of these rules is outside the scope of this document.

Materials covered by this RP are conventional Cr-Mo steels including standard 2¼Cr-1Mo and 3Cr-1Mo steels as well as advanced Cr-Mo steels, which include 2¼Cr-1Mo-¼V, 3Cr-1Mo-¼V-Ti-B, and 3Cr-1Mo-¼V-Nb-Ca steels. This document may be used as a reference document for the fabrication of pressure vessels made of enhanced steels (i.e., steels with mechanical properties increased by special heat treatments such as ASME SA-542, Grade B, Class 4) at the purchaser's discretion. However, no attempt has been made to cover specific requirements for the enhanced steels, and they may be different than the requirements for vanadium grade steels.

The interior surfaces of these heavy-wall pressure vessels may have an austenitic stainless steel weld overlay lining to provide additional corrosion resistance. A lining of stainless steel cladding using a roll-bonded or explosion-bonded layer on Cr-Mo base metal may be acceptable, but this is outside the scope of this document except as mentioned in 7.5.2.2. Roll-bonded cladding is generally not available with the base metal thicknesses covered by this document. However, if users extend the recommendation of this document to thinner material, roll-bonded cladding may be used. Multilayer vessels are also outside the scope of this document.

Heat exchanger shells and channels that meet the conditions listed above are within the scope of this RP. They are included in the term "pressure vessel" for the purposes of this RP.

This is the fourth edition of RP 934-A. The legacy first edition was API RP 934, *Materials and Fabrication Requirements for 2¼Cr-1Mo & 3Cr-1Mo Steel Heavy Wall Pressure Vessels for High Temperature, High Pressure Hydrogen Service*, published December 2000. The second edition was issued in May 2008, and it was the first version referred to as "934-A." RP 934-A, Second Edition, later incorporated Annex A and then Annex B, which were issued in February 2010 and March 2012 as Addendum 1 and Addendum 2, respectively. The third edition was issued in January 2019 with an Errata in September 2021.